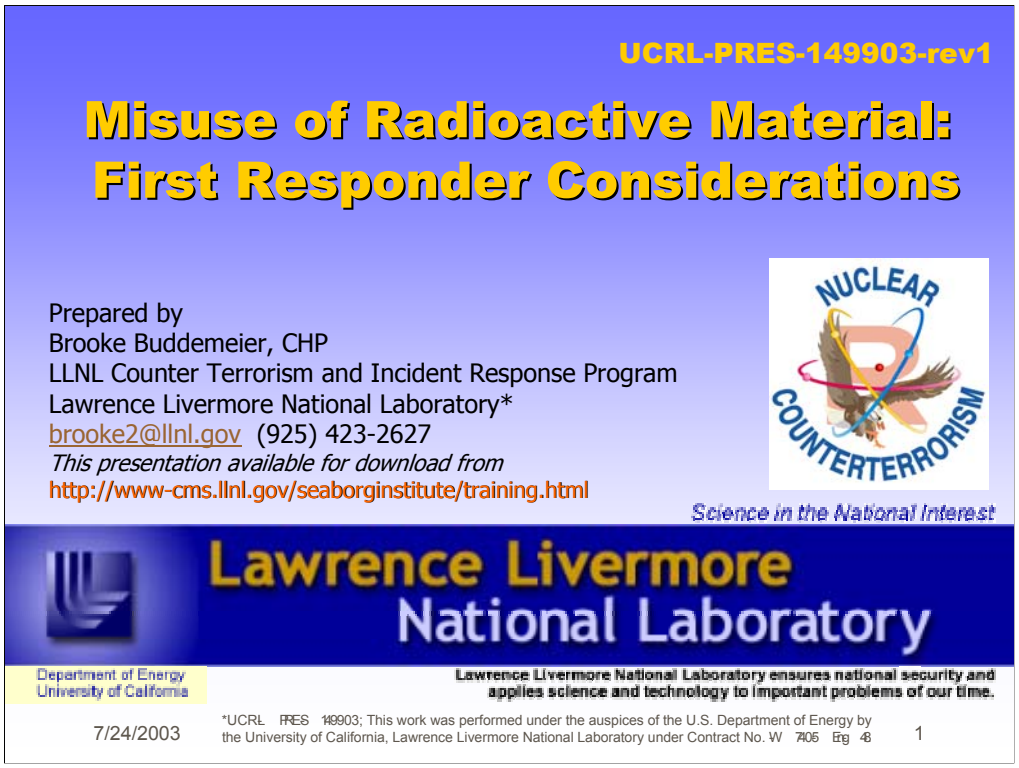

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First Responder Considerations

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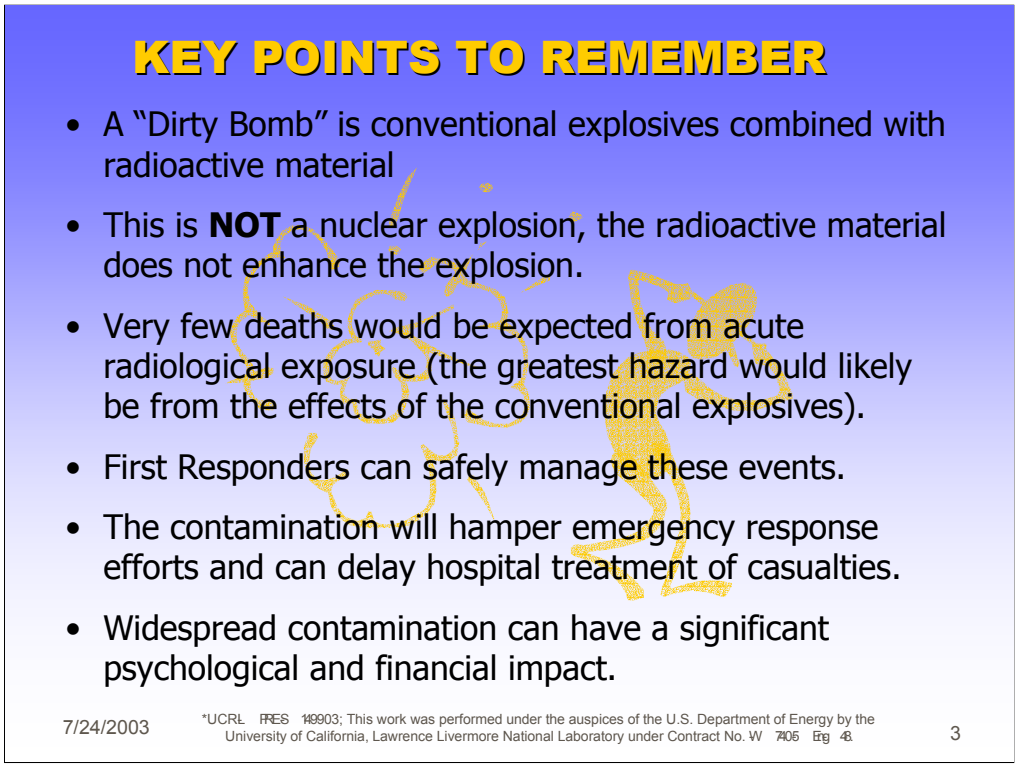
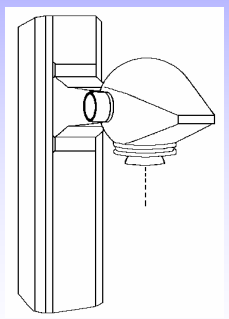


If it comes up, the older (cold war) definition of a 'Dirty Bomb' was used for nuclear weapons that created an excessive amount of fallout. However, the term currently used in the news media is the slang term defined above.

But this is NOT the current definition

A Case Study: Goiania, Brazil 1987

- When a hospital changed locations, a radiation therapy unit was temporarily left behind.
- Scrap metal hunters found the unit and dismantled it for scrap metal (~ Sept 18th).
- The 1.4 kiloCi (1,400 Ci) Cs-137 source containment was breached during the process.
- Pieces of source distributed to family and friends.
- Everyone was impressed by "the glowing blue stones." Children and adults played with them.
- Serious radiological accident recognized on Sept 29th when Acute Radiation Syndrome symptoms where recognized by hospital staff.



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Narrative:

In 1985, the Goiania Institute of Radiotherapy moved to a new location taking a Cobalt-60 teletherapy and discharging an obsolete Cesium-137 teletherapy unit in a partially demolished session of the old building in downtown Goiania

Two young men without permanent jobs looking for a way to make some money learned that there was a heavy equipment at an abandoned and partially demolished hospital building in downtown Goiania

Possibly on September 13, they forced the entrance of the building and decided to remove the shielding head of the teletherapy unit and sell it to a junk yard.

The two men, the owner of the junk yard and his two employees initiated attempts to dismantle the equipment

The rotating assembly and a capsule containing about 1400 Curies of Cesium-137 were dismantled presumably on September 18

The capsule was ruptured and the cesium released

Pieces of the source were distributed among the junk yard owner's relatives, neighbors and most close friends

Everyone was impressed with the "power of the stone" as it glowed blue in the dark.

Some of them scrubbed the material on the skin in order to appreciate its brightness

Residences about 100 miles from Goiania were found with cesium contamination

The owner's wife observed the occurrence of the first symptoms of acute radiation syndrome among her relatives and decided to look for medical assistance at the Hospital for Tropical Diseases

Pieces of the source were put in a bag that she took along with her by bus to the hospital

On September 29, the Brazilian Nuclear Energy Commission was notified by a goianian physicist about the occurrence of a serious radiological accident

Initial Response

112,000 people (10 % of Goiania's population) were surveyed at an Olympic Stadium.

- **250 were identified as contaminated**
- **50 contaminated people were isolated in a camping area inside the Olympic Stadium for more detailed screening**
- **20 people were hospitalized or transferred to special housing with medical and nursing assistance**
- **8 patients transferred to the Navy Hospital in Rio de Janeiro**
- **Residential contamination survey was initiated**

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Narrative: Read Slide

---------- notes ----------

Note: One the primary reasons I introduce this accident is so I can Use the Source in my dispersion modeling.

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Early Consequences

- Widespread contamination of downtown Goiania
- 85 residences found to have significant contamination (41 of these were evacuated and a few were completely or partially demolished)
- People cross-contaminated houses 100 miles away
- Hot Spots at 3 scrap metal yards and one house

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Radiation Injuries and Uptakes

- **4 fatalities (2 men, 1 woman and 1 child)**
- **28 patients had radiation induced skin injuries (they held/played with the source for extended periods)**
- **50 people had internal deposition (ingestion)**

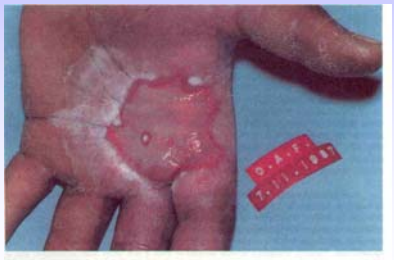
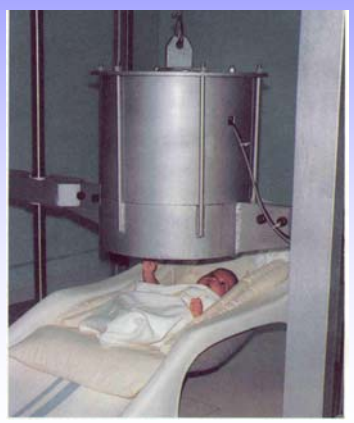


FIG. 9.3. 3–30 days after exposure. The skin was excised. A raw reddish surface is covered with a delicate layer of fibrinous exudate. Note the centripetal character of the healing process and the attempt of re-epithelialization.



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Critical phase of the ARS (acute radiation syndrome) characterized by hematological injury

14 patients developed bone marrow depression

8 had classical signs and symptoms of ARS

4 died due to bleeding diathesis and infection (sepsis) caused by Klebsiella

External Doses:

Estimated by chromosome aberration analysis

129 subjects evaluated

5 exceeded 3 Gy

16 exceeded 1Gy

24 exceeded 0.5 Gy

Internal Contamination/Exposure:

•In vitro bioassay (excreta samples were collected in Goiania and sent to IRD in Rio de Janeiro)

• In vivo measurements (a whole body counter was set up in Goiania in November at the General Hospital)

• 4 out of 8 patients transferred to the Navy Hospital in Rio de Janeiro were monitored in IRD before they were transferred back to Goiania in November

• In March 1988 a Bioassay Laboratory was set up in Goiania to perform in vivo and in vitro measurements during the follow up phase

•Ingestion was considered to be the main pathway

• 50 people isolated and hospitalized with internal and external contamination

• Prussian blue (ferric ferrocyanide) was administered to some individuals to enhance elimination

• 21 treated with Prussian blue (recommended dosage = 3 g/d)

•Intense psychological consequences amongst the population such as fear and depression.

• Discrimination against the victims and important products of local economy

• Large amounts of money spent during and after the recovering phases

• Need for the construction of a large deposit to store the radioactive waste

• Complete revision of Brazilian regulations related to the storage and use of radiation sources

Pictures obtained from "Radiation Emergency Assistance Services (SAER) from the Institute for Radiation Protection & Dosimetry (IRD), BRAZIL", or shortly SAER/IRD/Brazil.

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Radiological Considerations for Public Protective Actions

- EPA-established radiological ***public*** dose action levels to facilitate decision making
- Based on projected dose levels at which specific protective actions are warranted to reduce or eliminate the dose ***which is yet to be received***
  - Early Phase
    - Actions that need to be initiated quickly
    - Dose projected to those standing outside over the first 4 days
    - Evacuation, sheltering, administration of stable iodine
  - Intermediate Phase
    - Actions can be taken weeks to months after the accident
    - Dose projections to those living in the contaminated areas
    - Relocation, actions to avoid ingestion of contaminated foods

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Protective Action Guides (PAG)

- Early Phase
  - 4 day exposure to cloud ("plume") immersion, cloud inhalation, groundshine, and resuspension:
    - 1 REM: consider evacuation or sheltering
    - 5 REM: consider evacuation
    - 25 REM Thyroid Dose: consider administration of stable iodine
- Intermediate Phase
  - Exposure to groundshine and resuspended material
    - 2 REM in first year, 0.5 REM in "second" year, 5 REM in first 50 years are levels at which relocation should be considered
  - Dose from ingestion
    - Expressed as deposition Derived Response Levels (DRL/DIL)
    - "Preventative" levels: 0.5 REM (1.5 REM Thyroid Dose)
    - "Emergency" levels: 5 REM (15 REM Thyroid Dose)

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As an Example, if Brazil's Source was used as a "Dirty Bomb"

- This model makes unrealistic assumptions:
  - The source was 100% aerosolized
  - Lots of explosives (> 10 sticks of dynamite)
  - Presumes exposed populations "stood outside" during the 4 day exposure period
- Despite the accident in Brazil, sources of this strength are very difficult to obtain.

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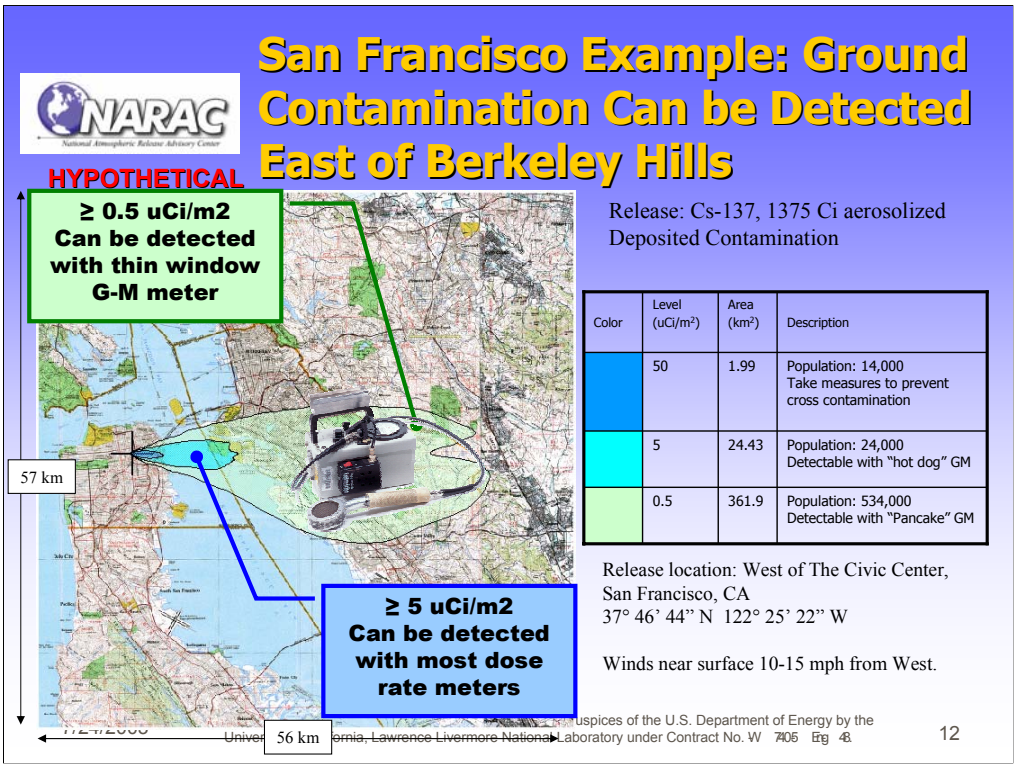
Very unrealistic scenario…. But it's just to provide you with a frame of reference.

Note Effects dependent on weather



Change this plot for the venue in which the presentation will be given. I can help arrange site specific plots: brooke2@llnl.gov

Point out that detectable contamination may be seen miles downwind

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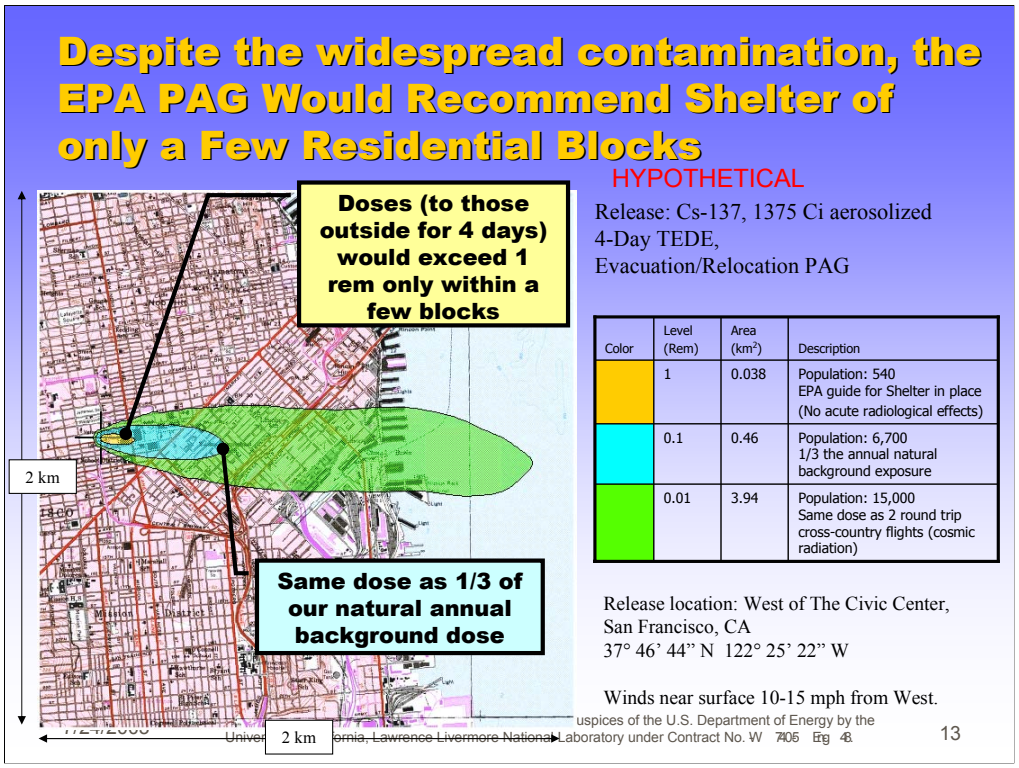

Despite the ease of detecting the material, the actual dose consequence to people breathing normally, standing downwind, outside for 4 days would get > 1 rem only on the small yellow area (~ 0.1 miles or a few blocks). This is from bother external and internal dose issues.

Although no acute health effects would be expected, this is the area that the EPA would recommend sheltering in place.

Out up to two miles, people are still getting an exposure, but it is on the order of a chest X ray or a tenth of everyone's annual natural background dose.

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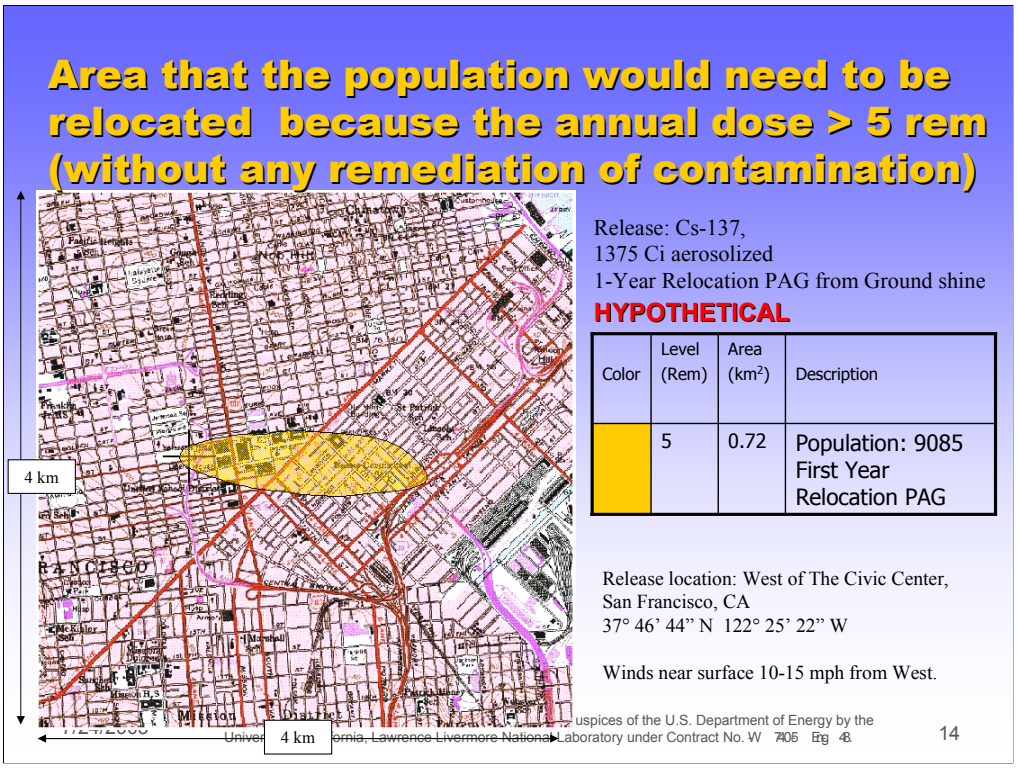

Let me be clear that remediation (i.e., clean up) is likely and that most of this area would be returned to service. This plot helps provide an idea of the area that we would need to relocate populations if the area was not cleaned up. Note that this is based on a 5 rem **annual** exposure, and relocation does not have to be done immediately, but rather in the weeks or months following the event.

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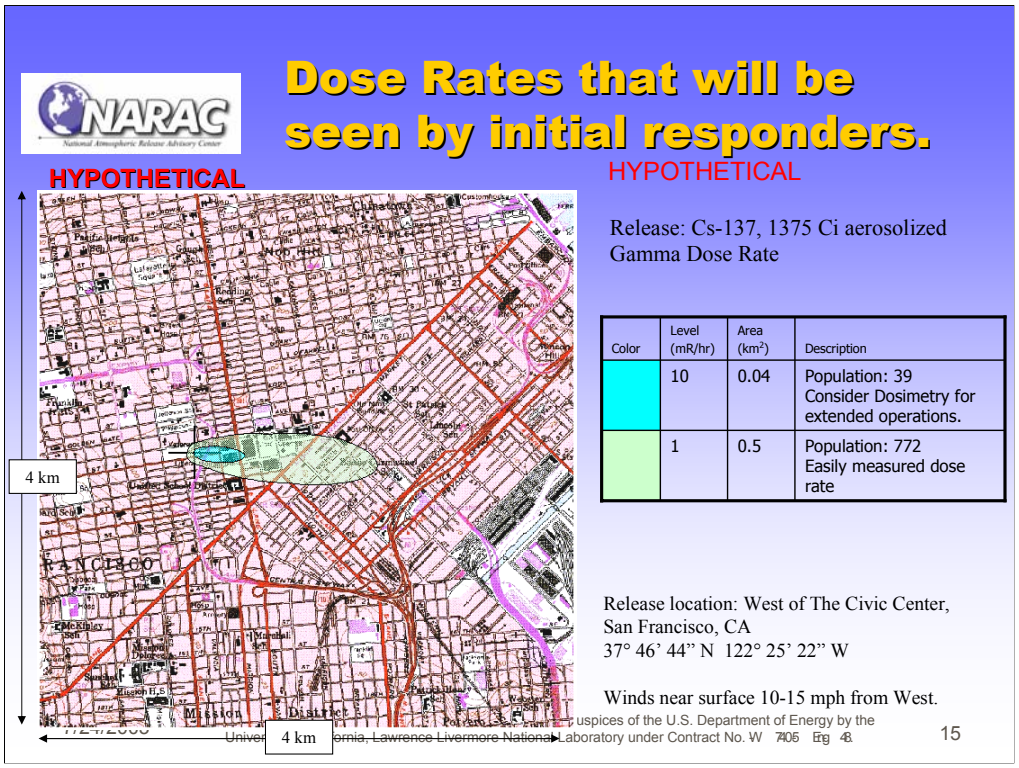

Here are the dose rates that first responders approaching the scene might see on their instruments from deposited contamination. Although easily detectable, it's not a hazard to work in.

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Site Contamination

The previous slides presumed 100% of the source material went "upward." It is more realistic that more than half of the material will remain at the explosion site.

This might create:

- High Dose Rates at the scene (> 1 R/hr)
- Highly contaminated "blast" victims
- An inhalation concern for responders

Note: These issues can be safely managed and should not result in delayed medical care of the victims

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In the previous slides, I made the unrealistic assumption that all the material was dispersed into the wind. It's likely that much of the contamination would be deposited at the scene of the explosion. With a strong source, like the one involved in the Brazilian accident, this could result high enough levels of contamination at the scene to:

1) Generate significant dose rates
2) Result in highly contaminated blast victims
3) represent an inhalation concern for responders.

Even if all of the above does occur, this should not result in the medical stabilization and evacuation of the victims at the scene.

The Respirators used by the police pictured above and Firefigher's turnouts and SCBA will provide effective protection form radiological inhalation concerns.

Contaminated victims can be gross decontaminated **after** medical stabilization.

And dose to responders can be controlled using the techniques discussed later in this presentation.

Picture from TOPOFF exercise

Even with Protective Clothing, RADIATION Can Still be a Hazard

- Hazardous radiation can occur from
  - High Levels of Contamination (ground shine)
  - A poorly distributed source (hot spots)
  - Intact sources (or pre-distribution)
- NCRP-138 "Management of Terrorist Events Involving Radioactive Material" recommends first responder "turn back" radiation levels of:
  - 10 R/hour, or
  - 10 rem total dose

(Note: responders can safely work at these levels if their exposure is monitored and work activities planned)

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Not all exploded sources will disintegrate. Responders should be careful to check that the intended RDD didn't simply bury a hot source in the ground or pavement.

These sources can actually be more dangerous as their external dose rates could over expose responders that stay in the area.

DO NOT delay treatment of Medical Emergencies For Radiological Concerns

- Stabilize and remove medical emergencies from the scene
- Decontaminate patients only if medically stable

"Gross Decon" (removal of outer clothing) removes most of the contamination

Patients can also be wrapped in blanket to prevent spread of contamination

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Nobody gets credit for a clean cadaver

It is **very** unlikely that anyone would be contaminated to the point of being a danger to themselves or rescue workers. But if not treated immediately, many blast trauma patients will die from the delay (or worse, aggressive decontamination).

If medically stable enough, simply removing their outer clothing will remove most of the contamination. Wrapping them in a blanket with help stop the spread of contamination during transport and treatment.

The secondary contamination from patients is not a major health issue, it is more of clean up concern.

Picture for TOPOFF exercise

Response to a Radiological Incident ~ Contamination ~

- Evacuate and "gross decon" victims (removal of outer clothing is an effective gross decontamination method)
- Monitor and isolate contaminated area
- Avoid breathing in radioactive material
  - Shelter in place (close windows, turn off heating and A/C)
  - Evacuate, when safe to do so
  - Wear respiratory protection
- Radioactive material will not be uniformly distributed. Radiation "Hot Spots" near the source of the event will be a hazard.

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Additional Steps to Mitigate High Contamination Hazards in the Immediate Area of a Release

- Approach and establish hotlines upwind
- Reduce Resuspension
  [Resuspension is the process of ground and plant contamination becoming airborne through the action of wind and/or activity]
  - Avoid activities that stir up dirt (driving, sweeping, etc..)
  - Apply "Fixative" (firefighting foam or even just misting water upwind of the site)

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High Contamination might be found in the immediate vicinity of a large radiological release. The high contamination area, usually smaller than a city block, can be recognized by the following traits:

1) High dose rates (> 1 R/hr), or
2) "Offscale" contamination meter readings (often > 100, 000 cpm)

Efforts need to be taken to keep this contamination from becoming airborne (this is called resuspension) where it can be inhaled by the public and responders downwind.

Review slide

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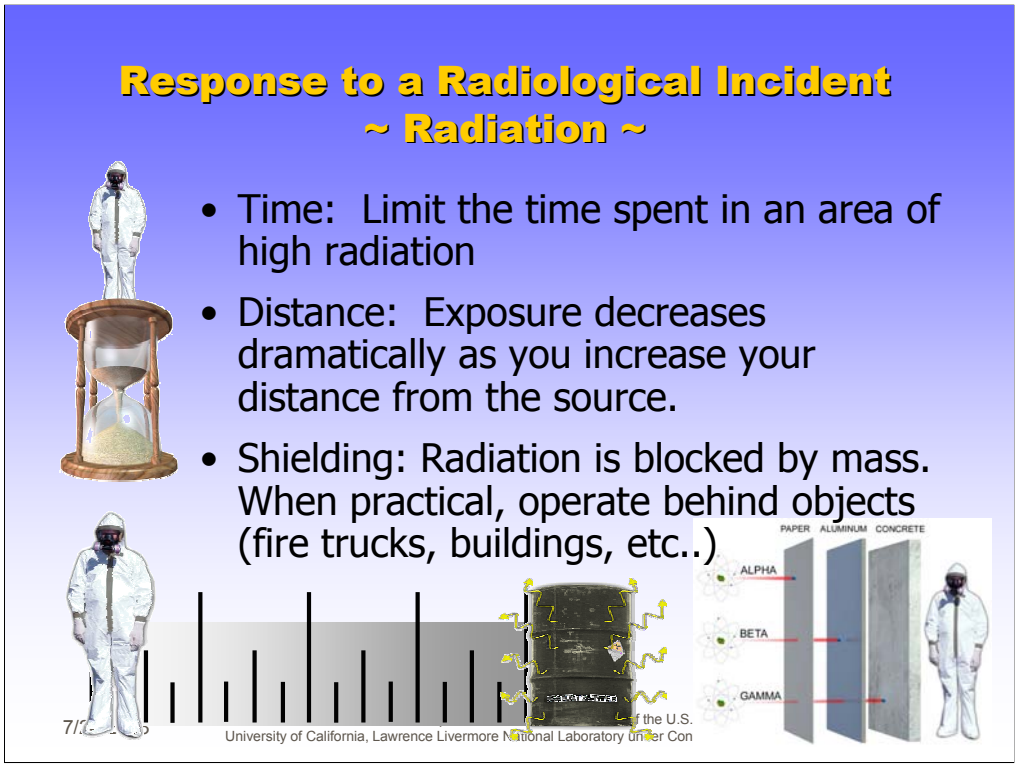

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Conclusion:
First Responder Considerations

- Acute health effects from radiation dose are unlikely without prolonged, high-concentration exposure.
- Contamination readily detectable at long distances.
- Medical emergencies take precedence over radiological monitoring.
- Wear respiratory protection, isolate area.
- Use decontamination techniques (removing outer clothing most effective)
- **Call for assistance**

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Dr. Henry B. Spitz, Professor of Nuclear and Radiological Engineering, Department of Mechanical, Industrial & Nuclear Engineering, University of Cincinnati
Dr. Jose Julio Rozental
Bernardo Dantas, Instituto de Radioprotecao Dosimetria, Brasil

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